

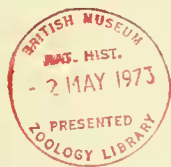
SYSTEMATIC COMPARISON OF THE
STROMATEID FISHES *STROMATEUS*
BRASILIENSIS FOWLER AND *STROMATEUS*
STELLATUS CUVIER FROM COASTAL SOUTH
AMERICA WITH A REVIEW OF THE GENUS

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Pp. 317-339; 9 *Text-figures*



BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
ZOOLOGY

Vol. 24 No. 7

LONDON: 1973

THE BULLETIN OF THE BRITISH MUSEUM
(NATURAL HISTORY), instituted in 1949, is
issued in five series corresponding to the Departments
of the Museum, and an Historical series.

*Parts will appear at irregular intervals as they become
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*This paper is Vol. 24, No. 7 of the Zoological series.
The abbreviated titles of periodicals cited follow those
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*World List abbreviation
Bull. Br. Mus. nat. Hist. (Zool.)*

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TRUSTEES OF
THE BRITISH MUSEUM (NATURAL HISTORY)

Issued 8 March, 1973

Price 95P

SYSTEMATIC COMPARISON OF THE STROMATEID FISHES *STROMATEUS* *BRASILIENSIS* FOWLER AND *STROMATEUS* *STELLATUS* CUVIER FROM COASTAL SOUTH AMERICA WITH A REVIEW OF THE GENUS

By MICHAEL H. HORN

SYNOPSIS

Two populations of stromateid fishes occur along opposite coasts off southern South America and are recognized as distinct species. The available names are *Stromateus brasiliensis* Fowler, 1906, for the Atlantic population and *Stromateus stellatus* Cuvier, 1829, for the Pacific population. These allopatric species can be completely distinguished on the basis of vertebral counts. Differences also exist in median fin-ray numbers, pectoral fin length, head length, and otolith length. The genus *Stromateus* is described and a key is provided to the three species. The third and quite distinct species, *S. fiatola*, occurs in the Mediterranean and off West Africa. The two South American species occupy an intermediate systematic position between *S. fiatola* and *Peprilus Snyderi*, the most primitive species of an advanced stromateid genus.

INTRODUCTION

Stromateus, one of the three genera of stromateid fishes (Haedrich, 1967), is widely distributed along the coasts of the Mediterranean, along the west African coast to Cape Town, and along the southern Atlantic and Pacific coasts of South America (Text-fig. 1). It is the only genus of the family with a transoceanic distribution—across the South Atlantic. According to Haedrich (1967), the genus contains the most primitive species of the family, *Stromateus fiatola*, but is not the direct ancestor of the other genera but rather must share a common ancestor with them.

Two apparently allopatric and quite similar populations of *Stromateus* occur in temperate waters on the continental shelf off the coast of South America—one off the Atlantic coast, and one off the Pacific coast. While names are available for each population, *Stromateus brasiliensis* Fowler, 1906, for the Atlantic population, and *S. stellatus* Cuvier, 1829, for the Pacific population, a junior synonym of the latter, *S. maculatus*, Cuvier and Valenciennes, 1833, is frequently applied to both populations. The status and relationships of the populations have long been uncertain. The availability of a series of specimens from both coasts has permitted a comparison of the two populations and provided a basis for the reinterpretation of specific relationships in the genus.

This paper presents a morphological and distributional comparison of the two populations and offers evidence for recognizing each as a separate species. The genus is reviewed, and an account is given of the distinct Eastern Atlantic and Mediterranean species, *S. fiatola*. The generic relationships in the family are discussed with particular emphasis on the limits, relationships, and zoogeography of *Stromateus* and *Peprilus*.

MATERIALS AND METHODS

Most of the specimens examined are in the British Museum (Natural History), London (BMNH), or were obtained from the Smithsonian Oceanographic Sorting Center, Washington, D.C. (SOSC). The latter are listed as uncatalogued specimens of the Museum of Comparative Zoology, Harvard University (MCZ). Other specimens studied are in the collections of the Academy of Natural Sciences, Philadelphia (ANSP), American University, Beirut, Lebanon (AUB), Museum National d'Histoire Naturelle, Paris (MNHN), Institut für Seefischerei, Hamburg (ISH), Zoological Museum, Copenhagen (ZMC), United States National Museum (USNM), the MCZ, and the Woods Hole Oceanographic Institution (WHOI). The AUB specimens are temporarily located at WHOI. The WHOI specimens will ultimately be catalogued in the MCZ. Fifteen specimens of *Stromateus brasiliensis* were received from the Instituto de Biología Marina, Mar del Plata, Argentina, and have not been deposited in an institution.

The methods of counting, measuring, and illustrating conform to those described by Horn (1970).

MATERIAL EXAMINED. The number of specimens, the range of standard lengths, and the locality appear in that order within the parentheses. Those specimens marked with an asterisk (*) have been radiographed. The number radiographed equals the number measured unless otherwise indicated.

Stromateus fiatola. *AUB P-717 (4 : 52.5-85.0 mm, Antelias, Lebanon); *BMNH 87.3.2.30 (1 : 75.3, Lower Congo); BMNH 98.9.10.1 (1:111.3, Mossel Bay, Cape of Good Hope, South Africa); BMNH 1920.9.7.3 (1 : 203.0, Nahr Rubin, near Jaffa, Israel); *BMNH 1922.1.13.56 (1 : 181.0, Durban, South Africa); *BMNH 1925.9.19.100-101 (2 : 64.9, 93.9, Port Said); BMNH 1929.8.31.4 (1 : 150.0, Port Said); *BMNH 1930.8.26.68 (1 : 294.0, Accra, Ghana); *BMNH 1938.11.1.61 (1 : 191.0, near Haifa, Israel); *MCZ 16729 (1 : 257.0, Mediterranean? from Vienna Museum); *WHOI uncat. (1 : 176.7, Nigeria, Federal Fishery Service of Nigeria No. 4046); *WHOI uncat. (6 : 199.8-240.0, Guinean Trawling Survey I Gulf of Guinea, 7° 20.5' N, 12° 40' W, 30 meters depth); *WHOI uncat. (2 : 195.0, 290.0, Guinean Trawling Survey II, Gulf of Guinea, 3° 28' S, 10° 36' E, 20 meters); ZMC 73-75 (3 : 26.5-34.6, near Naples Zoological Station, Italy).

Stromateus brasiliensis. ANSP 11354 (1 : 278.0, holotype of *Stromateus brasiliensis* Fowler, 1906, Rio Grande do Sul, Brazil); *BMNH 1925.6.10.1 (1 : 290.0, off northern coast of Tierra del Fuego); *BMNH 1932.6.9.1-3 (3 : 253.0-273.0, Falkland Islands); *BMNH 1935.9.11.8.9 (2 : 245.0, 283.0, off Uruguay, 34° S, 50° W); *BMNH 1936.6.9.1-10 (10 : 227.0-285.0, Falkland Islands); *BMNH 1936.8.26.1072-



FIG. 1. Distribution of *Stromateus*. The slanted lines indicate the total known distribution of each species. Localities from which specimens were examined in this study are represented by an X for *S. stellatus*, by a filled circle (●) for *S. brasiliensis*, and by a filled square (■) for *S. fiatola*. The question mark (?) in the northern part of the distribution of *S. stellatus* indicates the doubtful or rare occurrence of the species in that region.

74 (3 : 156.6-247.0, 44° 14' S, 63° 22' W); *BMNH 1936.8.26.1075-8 (4 : 266.0-308.0, off Argentina); *BMNH 1936.8.26.1079-83 (5 : 237.0-298.0, South Atlantic, 'DISCOVERY' Station W. S. 78/51.015, 91-93 meters); *BMNH 1936.8.26.1084-7 (5 : 112.2-167.3, South Atlantic, 'DISCOVERY' Station W. S. 847, 51-56 meters); *ISH 1463a-f/66 (6 : 116.0-285.6, South Atlantic, 45° 29' S, 66° 52' W, 'WALTHER HERWIG' Station 371/66, 85 meters, 4 radiographed); *ISH 1186/66 (1 : 254.0, South Atlantic, 36° 49' S, 54° 37' W, 'WALTHER HERWIG' Station 250/66, 100 meters); *MCZ 4599 (3 : 254.0-285.0, Rio Grande do Sul, Brazil); Uncatalogued (10 measured: 75.7-122.5, Mar del Plata, Argentina, received from Instituto de Biologia Marina, Mar del Plata, 15 radiographed).

Stromateus stellatus. *BMNH 1935.6-12.20-22 (3 : 139.6-163.2, Dichato, Chile); BMNH 1935.8.27.29-33 (5 : 102.6-220.0, Bahia de Coronch, Chile); MNHN 264.11.3.1-2 (2 : 144.3, 163.5, types of *Stromateus maculatus* Cuvier and Valenciennes, 1833, Valparaiso, Chile); *MCZ uncatalogued (10 : 50.5-99.4, 34° 03.6' S, 71° 58.4' W, R/V ANTON BRUUN Cruise 18A, Station 684, 40 meters); *MCZ uncatalogued (11 : 106.5-210.0, 35° 22' S, 72° 33' W, R/V ANTON BRUUN Cruise 18A, Station 688B, 27 meters); *MCZ uncatalogued (11 : 52.1-215.0, 37° 10.5' S 72° 21.5' W, R/V ANTON BRUUN Cruise 18A, Station 692, 18 meters); *MCZ uncatalogued (2 : 205.0, 240.0, near Corral, Chile, 39° 42' S, 73° 27' W, 36-45 meters); *USNM (1 : 193.0, Ancud, Chile, Chiloe Bay, 41° 52' S, 73° 53' W); WHOI uncatalogued (2 : 230.0, 237.0, Castro Bay, Chile, 42° 29' S, 72° 46' W).

SYSTEMATICS

Genus *STROMATEUS* Linnaeus, 1758

Stromateus Linnaeus, 1758 : 248. (Type species: *Stromateus fiatola* Linnaeus, 1758 : 248, by monotypy, Mediterranean.)

Chrysostrumus Lacépède, 1802 : 697. (Type species: *Chrysostrumus fiatoloides* Lacépède, 1802 : 697, by monotypy. Mediterranean. A synonym of *Stromateus fiatola* Linnaeus, 1758 : 248.)

Fiatola Cuvier, 1817 : 342. (Type species: *Stromateus fiatola* Linnaeus, 1758 : 248, by monotypy. Mediterranean.)

Seserimus Cuvier, 1817 : 342. (Type species: '*Seserimus Rondelet*' (*Seserimus rondeleti*) Cuvier 1817 : 343, by subsequent designation of Jordan, 1923 : 106. Mediterranean. A synonym of *Stromateus fiatola* Linnaeus, 1758 : 248.)

Pterorhombus Fowler, 1906 : 118. (Subgenus. Type species: *Fiatola fasciata* Risso, 1826 : 289, by original designation. Mediterranean. A synonym of *Stromateus fiatola* Linnaeus, 1758 : 248.)

DIAGNOSIS. The genus *Stromateus* is distinguished from other stromateid genera by the combination of moderately deep body, moderately long pectoral fins, usually five to seven small spines anterior to the rays of the dorsal fin, spotted body pattern, pelvic fins in the young (of one species), and no ventral spine on the pelvic bone. *Stromateus* is particularly distinguished from *Pampus* in having six rather than five branchiostegal rays and in having a movable rather than a fixed maxillary bone. *Stromateus* is further distinguished from *Peprilus* in having 41 to 49 vertebrae versus 29 to 36.

DESCRIPTION. Body moderately deep to elongate, depth 31 to 53 per cent of standard length, highly compressed. Caudal peduncle short, slender, and compressed. Dorsal and ventral profiles convex and similar, anterior dorsal profile slightly to moderately convex. Snout short and blunt, jaws equal. Eye small to moderate with surrounding adipose tissue reaching to nostrils; eye diameter either equal to or less than length of snout depending upon age. Nostrils double, anterior round, posterior a slit, moderate in size, directly anterior to eye, near end of snout. Dorsal and anal fins with long base, similar to each other, slightly to moderately falcate as produced by elongation of the first 10 to 13 rays; dorsal and anal coterminous, just anterior to caudal peduncle. Dorsal fin with five to seven small spines anterior to and continuous with the fin-rays; 42 to 56 total elements. Anal fin shorter than dorsal (fewer rays), with usually two or three small spines preceding and continuous with the fin-rays; 33 to 48 total elements. Posteriormost spines of anal and dorsal often difficult to distinguish from anteriormost soft rays. Pectoral fin lateral, just below level of eye, moderately long, either somewhat fan-like or pointed, base of fin slightly inclined, 15 to 30 per cent of standard length; 18 to 25 rays. Pelvic fins present in the juveniles of one species; small, inserting under end of pectoral fin base; fins absent in adult but two dark skin flaps often indicate the former presence of fins. No ventral spine on pelvic bone. Caudal fin moderately long to very long, moderately to deeply forked, about 17 to 32 per cent of total length; lobes equal.

TABLE I. Number of dorsal fin elements in species of *Stromateus*.

Species	4 ²	4 ³	4 ⁴	4 ⁵	4 ⁶	4 ⁷	4 ⁸	4 ⁹	4 ¹⁰	4 ¹¹	4 ¹²	4 ¹³	4 ¹⁴	4 ¹⁵	4 ¹⁶	4 ¹⁷	4 ¹⁸
<i>brasiliensis</i>						2	5	3	11	12	7	3	4	1	2		
<i>stellatus</i>	1		1	1	3	9	10	10	9	1							
<i>fiatola</i>	1	2	5	4	3	2	4	2	2								

TABLE II. Number of anal fin elements in species of *Stromateus*.

Species	3 ³	3 ⁴	3 ⁵	3 ⁶	3 ⁷	3 ⁸	3 ⁹	3 ¹⁰	3 ¹¹	3 ¹²	3 ¹³	3 ¹⁴	3 ¹⁵	3 ¹⁶	3 ¹⁷	3 ¹⁸
<i>brasiliensis</i>								1	6	7	9	11	6	5	2	1
<i>stellatus</i>				1		3	8	8	10	9	4	2	1			
<i>fiatola</i>	3	8	8	3	2	1										

TABLE III. Number of pectoral fin-rays in species of *Stromateus*.

Species	1 ⁸	1 ⁹	1 ²⁰	1 ²¹	1 ²²	1 ²³	1 ²⁴	1 ²⁵
<i>brasiliensis</i>	1	7	21	19	2	2	1	
<i>stellatus</i>		8	17	20	2			
<i>fiatola</i>				3	4	9	7	2

TABLE IV. Number of gill rakers in species of *Stromateus*.

Species	1 ⁴	1 ⁵	1 ⁶	1 ⁷	1 ⁸	1 ⁹	1 ²⁰	1 ²¹	1 ²²	1 ²³
<i>brasiliensis</i>					4	11	17	12	5	
<i>stellatus</i>				1	5	12	11	15	2	
<i>fiatola</i>	2	1	1	12	6	2				

TABLE V. Number of vertebrae in species of *Stromateus*.

Species	41	42	43	44	45	46	47	48	49
<i>brasiliensis</i>					4	24	14	9	3
<i>stellatus</i>	3	6	32	4					
<i>fiatola</i>			4	13	3				

Scales small, cycloid, irregular in shape, deciduous, very small scales extending on to fins; cheek, suborbital area, preopercle, and sometimes opercle scaled; top of head and nape generally scaleless; scales usually absent in preserved material. Lateral line of trunk of simple, tubed scales which are often less deciduous than those of rest of body; lateral line above intermuscular septum, following dorsal profile and extending onto caudal peduncle but not to base of caudal fin. A branch of lateral line extends from immediately above eye posteriorly to head of hyomandibula where it joins a similar branch then turns upward toward mid-dorsal line in a wide, bony tract; not visible in all specimens. Cephalic lateral line of pores and canals on cheek, opercular area, snout, lower jaw, and top of head. Subdermal canal system apparently not well developed; pores on trunk lacking, top of head and nape underlain by a series of dendritic canals. As in other stromateoids, distinction between cephalic lateral line components and subdermal canal system not clear. Head length about 20 to 35 per cent of standard length depending upon species and age. Premaxilla not protractile, maxilla movable and not or just barely reaching anterior edge of eye; lacrimal bone reduced; end of maxilla exposed when mouth is closed. No supramaxilla. Jaw teeth small, uniserial, close-set, laterally flattened, usually with three subequal cusps, covered laterally by a membrane. Vomer, palatines, and basibranchials toothless. Gill membranes united across isthmus, divided from about level of anterior part of eye. Opercle and preopercle thin, flat, margins entire; opercle rounded, with two weak, ill-defined spines; angle of preopercle broadly rounded, projecting backward slightly. Gill rakers similar among the species, slightly less than one-half the length of the filaments, not toothed, fairly closely set, three to eight on epibranchial, one at junction of elements, and 10 to 15 on lower elements of first arch (cerato- and hypobranchials). Pseudobranch with no rudimentary rakers. Six branchiostegal rays, four on ceratohyal, two on epihyal. Vertebrae 41 to 49, 17 to 21 precaudal, 24 to 30 caudal. Three free interneurals ahead of dorsal fin. Two or three epural and four hypural elements in caudal apparatus. Sclerotic bones well ossified. Toothed pharyngeal sac behind last gillarch, joining tubular esophagus; stomach a simple sac; intestine long and in loops, about two to three times the standard length of the body; pyloric caeca numerous, short, in a dendritic mass adjacent to stomach. Swimbladder thin-walled, physoclistous, continuous with dorsal peritoneum, regressed in fishes larger than about 75 to 100 mm SL. Buccal and pharyngeal cavities light in colour; peritoneum silvery with a peppering of black pigment. Gonads paired, in postero-dorsal region of body cavity; ovary in mature and maturing individuals elongate, yellowish, and granular; eggs in ripe ovary spherical, yellowish, less than one millimeter in diameter; testis in mature and maturing specimens elongate, yellowish-white, and smooth in texture. No external sexual dimorphism apparent.

Colour in life iridescent bluish or greenish-silver dorsally to silver ventrally; numerous spots of varying colour on dorsal and upper ventral surfaces. The young of one species have five to nine dark vertical bands. Colour in preservative varying from bluish-brown to brown dorsally to silver ventrally or body completely brown or bluish-brown. The round or nearly round spots are dark in preservative and tend to disappear in one species. Individual melanophores conspicuous in specimens up to about 80 to 100 mm SL. Fins may be darker or lighter than the body; melanophores present on the membranes between the fin-rays. Eye usually darker than rest of body; lens opaque surrounded by iris which may be black, partly black and partly yellowish-white, or all yellowish-white

KEY TO THE SPECIES OF *Stromateus*

- 1 (2) Vertical bars on sides and pelvic fins present in juveniles of usually less than 100 mm SL; two dark skin flaps or scars indicate former presence of pelvic fins in adults; spots of varying colour on adults but usually lost in preservation; 33 to 38 total anal fin elements (Text-figs 2 and 3) *S. fiatola* Linnaeus, 1758
- 2 (1) Vertical bars and pelvic fins never present; dark spots along upper sides of body, the number generally increasing with age; 36 to 48 total anal fin elements 3
- 3 (4) Vertebrae 45 to 49; total dorsal fin elements 47 to 56; total anal fin elements 40 to 48; pectoral fin relatively short, 15 to 26 per cent of SL (Text-fig. 4) *S. brasiliensis* Fowler, 1906
- 4 (3) Vertebrae 41 to 44; total dorsal fin elements 42 to 51; total anal fin elements 36 to 46; pectoral fin relatively long, 23 to 30 per cent of SL (Text-fig. 5) *S. stellatus* Cuvier, 1829

Stromateus fiatola Linnaeus, 1758

(Text-figs 2 and 3)

Stromateus fiatola Linnaeus, 1758 : 248 (original description, Mediterranean, holotype not seen); Regan, 1902 : 203; Pellegrin, 1905 : 137; Metzelaar, 1919 : 227; Chabanaud and Monod, 1926 : 261, fig. 21; Fowler, 1936 : 672, fig. 303; Irvine, 1947 : 195, fig. 115; Barnard, 1947 : 193, Pl. XXXII, fig. 5; Smith, 1949 : 841; 1961 : 303, Pl. 63; Ben-Tuvia, 1953 : 19; Haedrich, 1967 : 102, fig. 39.

Chrysostomus fiatoloides Lacépède, 1802 : 697 (original description, Mediterranean, holotype not seen).

Seserinus rondeleti Cuvier, 1817 : 343 (original description, Mediterranean, holotype not seen).

Fiatola fasciata Risso, 1826 : 289 (original description, Nice, Mediterranean, holotype not seen); Fowler, 1906 : 118.

Seserinus microchirus Cuvier and Valenciennes, 1833 : 416 (original description, holotype not seen); Regan, 1902 : 204; Gilchrist and von Bonde, 1923 : 11, pl. XIX.

Stromateus capensis Pappe, 1853 : 26 (original description, Cape Town, South Africa, holotype not seen); Gilchrist and von Bonde, 1923 : 11; Fowler, 1925 : 212.

Stromateus microchirus, Günther, 1860 : 398; Pellegrin, 1905 : 137; Gilchrist and von Bonde, 1923 : 11.

Stromateus fasciatus, Fowler, 1936 : 673; Smith, 1949 : 841; 1961 : 303, pl. 97; Ben-Tuvia, 1953 : 19.

DIAGNOSIS. *S. fiatola* is a moderately deep to elongate species distinguished from the two other species of *Stromateus* in that the juveniles have pelvic fins and dark vertical bands. The scars or remnants of the pelvic fin remain in the adults.

DESCRIPTION. Proportional measurements are given in Table VI and meristic values in Table VII. Body moderately deep to elongate, anterior dorsal profile slightly to moderately convex. Eye diameter usually less than length of snout. Dorsal fin most frequently with five small spines and anal fin with two or three small spines preceding the rays. Pectoral fin somewhat rounded, fan-like. Pelvic fins small, disappearing with age with only dark flaps of skin or scars remaining. Caudal fin long to very long, moderately to deeply forked, about 22 to 32 per cent of total length. Three epural elements in caudal structure.

Colour in life iridescent blue or green with silvery aspect ventrally. Young have five to nine dark vertical bands which disappear with age; adults have spots over much of the upper surface of the body which vary from yellow to black in colour and from oblong to round in shape. Vertical bands of young usually remain visible in preservative but spots of adult often disappear to give uniform brown or bluish-brown colour.

Maximum length probably about 500 mm SL.

VARIATION. Coefficients of variation (V) for proportional measurements range from nine to 25 (Table VI) and from one to about seven for meristic characters (Table VII). *S. fiatola* is more highly variable in the morphological characters studied than the other two species of *Stromateus*, and this is largely associated with ontogenetic changes which are described below.

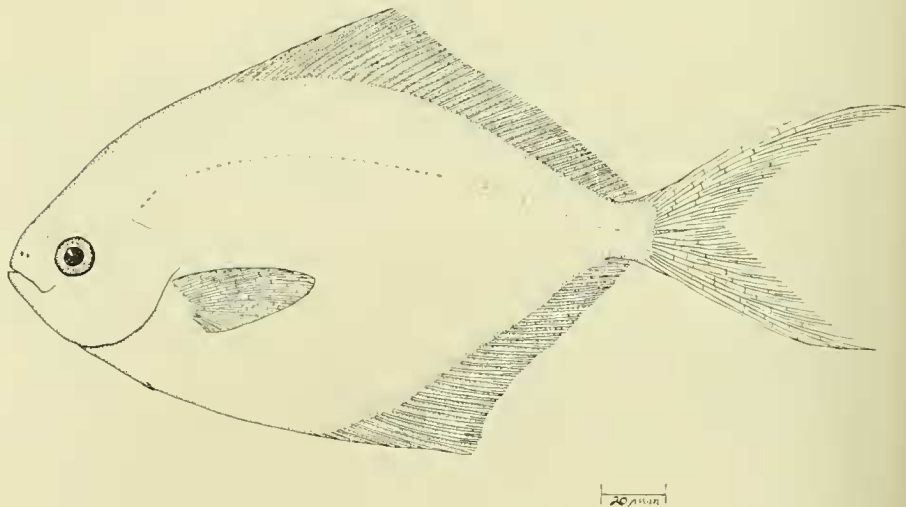


FIG. 2. *Stromateus fiatola*, 207.6 mm SL, 7° 20.5' N, 12° 40' W, Guinean Trawling Survey I. Spots usually present on fish of this size have disappeared on this specimen in preservative.

The frequency distribution of the number of dorsal fin-rays, anal fin-rays, pectoral fin-rays, gill rakers, and vertebrae for this and the other two species are presented in Tables I and V, respectively.

No geographic variation was detected in this species.

S. fiatola undergoes comparatively marked changes with age and to such an extent that the juveniles and adults have frequently been treated as separate species. *S. fasciatus* and *S. microchirus* are the names most often applied to the juveniles (see synonymic list above). The juveniles have five to nine dark vertical bands on the sides of the body and small pelvic fins. At a size of 100 mm SL, the fish has lost the vertical bands and the pelvic fins although small skin flaps or scars may persist in the pelvic area. The swimbladder is usually completely regressed by the time the fish reaches the above size.

The adults have spots of varying size and colour on the sides of the body. No marked morphometric changes occur with age although head length, eye diameter, and upper jaw length tend to decrease as a percentage of SL with age.

DISTRIBUTION. (Text-fig. 1) *S. fiatola* occurs throughout the Mediterranean Sea and along the Atlantic coast of Africa south to Cape Town. The species is confined to the continental shelf and inhabits relatively shallow water. Poll (1959) reported the adults to be common in depths of 12 to 50 meters off the coast of West Africa. Longhurst (1965) listed the fish as one of the associated species (i.e., not dominant) in the 'sub-thermocline sparid sub-community' on the Nigerian continental shelf.

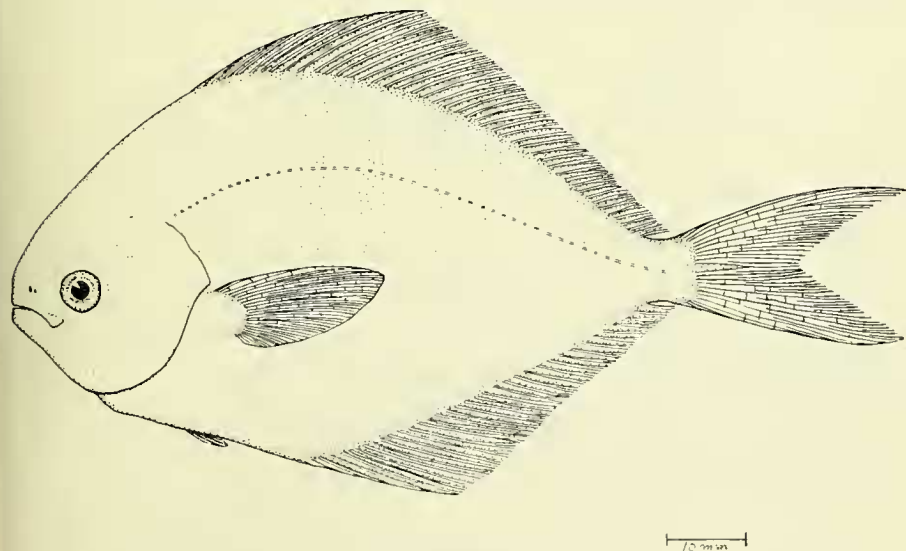


FIG. 3. *Stromateus fiatola*, 85.0 mm SL, eastern Mediterranean, off coast of Lebanon.

This sub-community begins at a depth of 45 to 50 meters and near the 20°C isotherm and is found over both hard and soft deposits below the thermocline to near the continental edge. Juveniles frequently occur with jellyfish medusae in surface waters.

TABLE VI. Proportional measurements of *Stromateus fiatola*. N = number of specimens; R = range of values; \bar{X} = mean; SE = standard error of mean; V = coefficient of variation. Size range, 26.5–294.0 mm SL; mean size, 153.4 mm SL.

	N	R	\bar{X}	SE	V
In thousandths of SL:					
Head length (HL)	26	225–351	271	6.93	13.05
Snout length	26	060–095	076	1.71	11.47
Eye diameter	26	035–092	062	3.07	25.26
Length of upper jaw	26	060–128	082	3.60	22.40
Interorbital width	26	091–133	109	2.41	11.27
Length of pectoral fin	26	183–267	224	4.70	10.71
Predorsal distance I	25	297–438	362	8.02	11.08
Predorsal distance II	24	201–312	237	6.17	12.76
Preanal distance	26	417–596	485	9.34	9.82
Maximum depth of body	26	359–529	470	9.54	10.35
Least depth of caudal peduncle	26	068–098	085	1.58	9.48
In thousandths HL:					
Eye diameter	26	155–289	224	6.01	13.67
			Mean V value		13.44

TABLE VII. Meristic values of *Stromateus fiatola*. Symbols as in Table VI.

	N	R	\bar{X}	SE	V
Dorsal fin rays*	25	42–50	46.0	0.45	4.87
Anal fin-rays*	25	33–38	34.8	0.26	3.68
Pectoral fin-rays	25	21–25	23.0	0.23	4.96
Total gill rakers	24	14–19	17.0	0.26	7.47
Total vertebrae	20	43–45	44.0	0.14	1.39
			Mean V value		4.47

* Total fin elements

Stromateus brasiliensis Fowler, 1906

(Text-fig. 4)

Stromateus brasiliensis Fowler, 1906 : 116, fig. 2 (original description, Rio Grande do Sul, Brazil, holotype seen, 278.0 mm SL, ANSP 11354); Haedrich, 1967 : 102.

Stromateus maculatus, Norman, 1937 : 118 (of *S. maculatus* Cuvier and Valenciennes 1833 : 399, in part—the population on the Atlantic coast of South America); Fordice, 1884 : 314, in part, specimen of description from Atlantic, but gives coast of Chile as the habitat; Abbot, 1899 : 337, in part, gives Atlantic coast northward to Patagonia as part of distribution; Hart, 1946 : 359.

DIAGNOSIS. *S. brasiliensis* is an elongate species with round, dark spots on the dorsal and upper ventral surfaces and with no pelvic fins. It is distinguished from the closely related *S. stellatus* by having 45 to 49 vertebrae compared to 41 to 44 in

S. stellatus. Characters that distinguish *S. brasiliensis* from *S. fiatola* are listed in the diagnosis of the latter species.

DESCRIPTION. Proportional measurements are given in Table VIII and meristic values in Table IX. Body elongate, anterior dorsal profile slightly convex. Dorsal fin usually with about five to seven small spines and anal fin with two or three small spines preceding the rays. Pectoral fin somewhat rounded, fan-like. No pelvic fins. Caudal fin moderately long to long, moderately forked, about 17 to 22 per cent of total length. Two epural elements in caudal structure.

Colour generally as described for the genus. The young in preservative have round, dark spots on the dorsal surface as do the adults, the number of spots increasing with age.

Maximum length probably about 450 mm SL.

VARIATION. Coefficients of variation (V) for proportional measurements range from about 5 to about 28 (Table VIII) and from about 2 to about 5 for meristic characters (Table IX).

No geographic variation was detected in this species.

S. brasiliensis does not undergo striking changes with age. The number of spots on the body tends to increase with size, and eye diameter as a percentage of SL decreases with increase in size of the fish.

DISTRIBUTION. (Text-fig. 1) *S. brasiliensis* occurs along the Atlantic coast off southern South America from southern Brazil to the Falkland Islands and beyond to Tierra del Fuego, almost to 55° S, and as far eastward in this southern vicinity as 57° W.

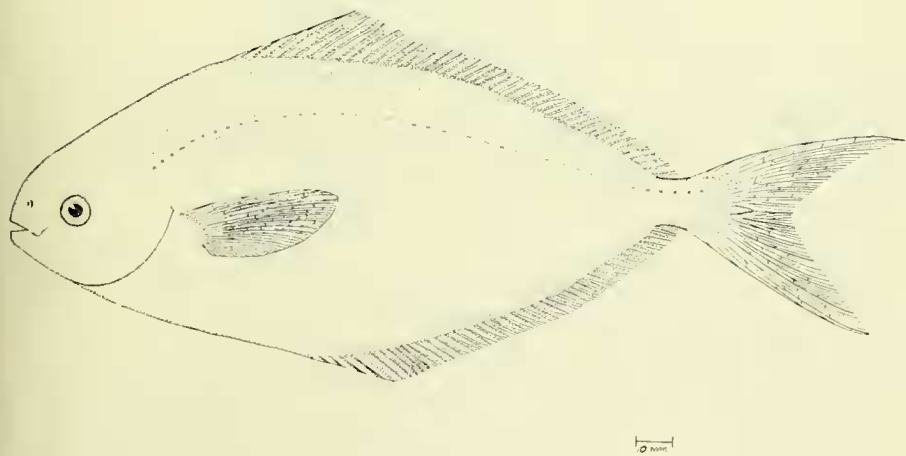


FIG. 4. *Stromateus brasiliensis*, 204.0 mm SL, 45° 29' S, 66° 52' W, 'Walther Herwig' Station 371/66.

TABLE VIII. Proportional measurements of *Stromateus brasiliensis*. Symbols as in Table VI. Size range, 75.7-308.0 mm SL; mean size, 210.4 mm SL.

	N	R	\bar{X}	SE	V
In thousandths of SL:					
Head length (HL)	54	198-305	235	2.78	8.70
Snout length	50	053-083	068	0.95	9.93
Eye diameter	50	031-085	050	1.99	28.16
Length of upper jaw	50	048-077	059	1.03	12.36
Interorbital width	49	067-106	084	1.44	11.99
Length of pectoral fin	54	154-259	216	3.29	11.18
Predorsal distance I	50	268-451	314	6.15	13.85
Predorsal distance II	49	179-271	216	3.14	10.01
Preanal distance	49	388-502	427	3.32	5.44
Maximum depth of body	54	310-463	398	4.56	8.43
Least depth of caudal peduncle	50	052-084	066	0.97	10.44
In thousandths of HL:					
Eye diameter	50	146-296	208	6.05	20.57
			Mean V value		12.59

TABLE IX. Meristic values of *Stromateus brasiliensis*. Symbols as in Table VI.

	N	R	\bar{X}	SE	V
Dorsal fin-rays*	50	47-56	51.0	0.30	4.16
Anal fin-rays*	48	40-48	43.1	0.29	4.64
Pectoral fin-rays	53	18-24	20.5	0.15	5.27
Total gill rakers	49	18-22	20.1	0.16	5.52
Total vertebrae	54	45-49	46.7	0.14	2.21
			Mean V value		4.36

* Total fin elements.

Stromateus stellatus Cuvier, 1829

(Text-fig. 5)

Stromateus stellatus Cuvier, 1829 : 213 (original description, coast of Peru, holotype not seen); Haedrich, 1967 : 102.

Stromateus maculatus Cuvier and Valenciennes, 1833 : 399 (original description, Valparaiso, Chile, holotype not seen); Guichenot, 1848 : 248, pl. 3, fig. 1; Fordice, 1884 : 314 (in part, lists coast of Chile in distribution but specimen of description from Rio Grande do Sul, Brazil); Abbott, 1899 : 314 (in part, Pacific coast); Regan, 1902 : 204; Evermann and Radcliffe, 1917 : 64; Norman, 1937 : 118 (in part, Pacific coast).

DIAGNOSIS. *S. stellatus* is an elongate species closely related to *S. brasiliensis* and has round, dark spots on the dorsal and upper ventral surfaces and no pelvic fins. Characters which distinguish the species from *S. brasiliensis* and *S. fiatola* are listed in the diagnosis of each of those species, respectively.

DESCRIPTION. Proportional measurements are given in Table X and meristic values in Table XI. Body elongate, anterior dorsal profile slightly convex. Dorsal fin with about five to seven small spines and anal fin with two or three small spines preceding the rays. Pectoral fin somewhat pointed. No pelvic fins. Caudal fin moderately long to long, moderately forked, about 20 to 24 per cent of total length. Two epural elements in caudal structure.

Colour generally as described for the genus. Small juveniles in preservative sometimes have no spots, but most frequently round, dark spots are present on the body and generally increase in number with age.

Maximum length probably 400 mm SL.

VARIATION. Coefficients of variation (V) for proportional measurements range from about 4 to 33 (Table X) and for meristic characters from about 2 to about 6 (Table XI).

No geographic variation was noted in this species.

S. stellatus does not undergo marked changes with age and has the lowest mean V values of the three species for the characters considered. However, eye diameter expressed as a percentage of SL has the greatest variation among the species and is due to change with age, the eye becoming relatively smaller. As in *S. brasiliensis*, the number of spots on the body tends to increase with age.

DISTRIBUTION. (Text-fig. 1) *S. stellatus* occurs along the Pacific coast off South America from southern Peru to southern Chile. Valenciennes (quoted in Cuvier (1829) and Abbott (1899)) stated that the fish was common in the fish markets of Lima from May to July; however, it probably occurs only infrequently or seasonally this far north. The most southerly locality encountered in the present study was Castro Bay, Chile at 42° 29' S. *S. stellatus* probably seldom occurs as far south as Tierra del Fuego.

TAXONOMIC COMMENTS. Whitley (1935) described a new species of *Stromateus*, *S. advectitius*, from a rough sketch of a fish collected on an Australian voyage (to New South Wales) in the late 1700's. The fish was later tentatively referred to as

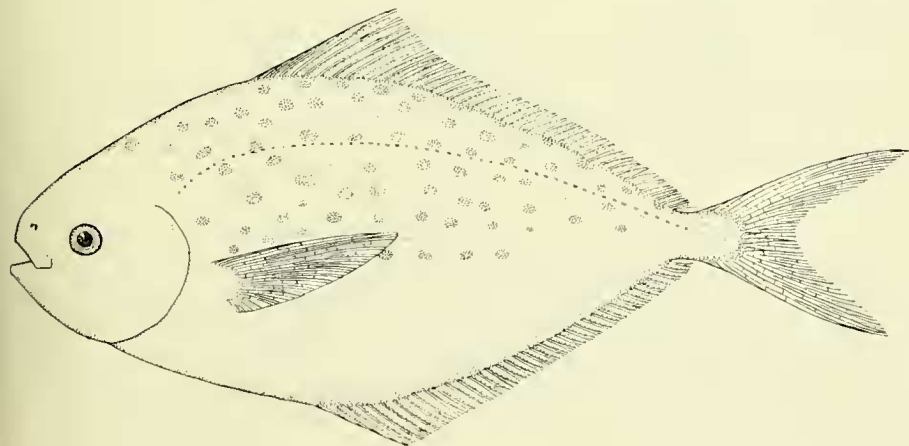


FIG. 5. *Stromateus stellatus*, 180.0 mm SL, 35° 22' S, 72° 33' W, R/V Anton Bruun Cruise 18A, Station 688B.

Stromateus? maculatus. Because Whitley was not certain of the identity and because *S. maculatus* was preoccupied, he named it *S. advectinus*. However, no other record of *Stromateus* from the southwestern Pacific exists, and the fish was quite likely not a member of this genus. The identity of this fish remains unknown.

TABLE X. Proportional measurements of *Stromateus stellatus*. Symbols as in Table VI. Size range, 50.5-240.0 mm SL; Mean size, 139.0 mm SL.

	N	R	\bar{X}	SE	V
In thousandths of SL:					
Head length (HL)	47	240-347	280	4.03	9.87
Snout length	47	068-082	077	0.50	4.42
Eye diameter	47	038-104	066	3.17	33.00
Length of upper jaw	46	055-091	070	1.32	12.80
Interorbital width	47	078-108	096	1.75	12.49
Length of pectoral fin	45	229-304	274	3.06	7.49
Predorsal distance I	46	302-396	340	3.86	7.70
Predorsal distance II	45	214-309	253	4.31	11.42
Preanal distance	47	404-483	437	2.56	4.01
Maximum depth of body	47	342-423	392	2.86	5.01
Least depth of caudal peduncle	47	057-070	064	0.45	4.88
In thousandths of HL:					
Eye diameter	47	158-347	229	7.88	23.61
			Mean V value		11.39

TABLE XI. Meristic values of *Stromateus stellatus*. Symbols as in Table VI.

	N	R	\bar{X}	SE	V
Dorsal fin-rays*	45	42-51	48.1	0.17	2.33
Anal fin-rays*	46	36-46	40.8	0.28	4.58
Pectoral fin-rays	47	19-22	20.3	0.12	4.04
Total gill rakers	46	18-23	20.0	0.18	5.60
Total vertebrae	45	41-44	42.8	0.10	1.61
			Mean V value		3.65

* Total fin elements.

Comparison of *S. brasiliensis* and *S. stellatus*

The populations of *Stromateus* off the coasts of southern South America are quite similar and closely related. However, divergence in several morphological features has occurred, and two distinct populations are easily recognized. The populations are apparently allopatric—there are no records for extreme southern South America (Text-fig. 1). Because there has been no post-isolation contact of the divergent populations, the decision as to their taxonomic rank must remain a somewhat arbitrary one.

The two populations can be completely separated on the basis of vertebral number, the Atlantic form (*S. brasiliensis*) having 45 to 49 vertebrae and the Pacific form (*S. stellatus*) 41 to 44. Although vertebral number as a systematic character must often be used with caution, it can be used with some confidence in stromateid fishes.

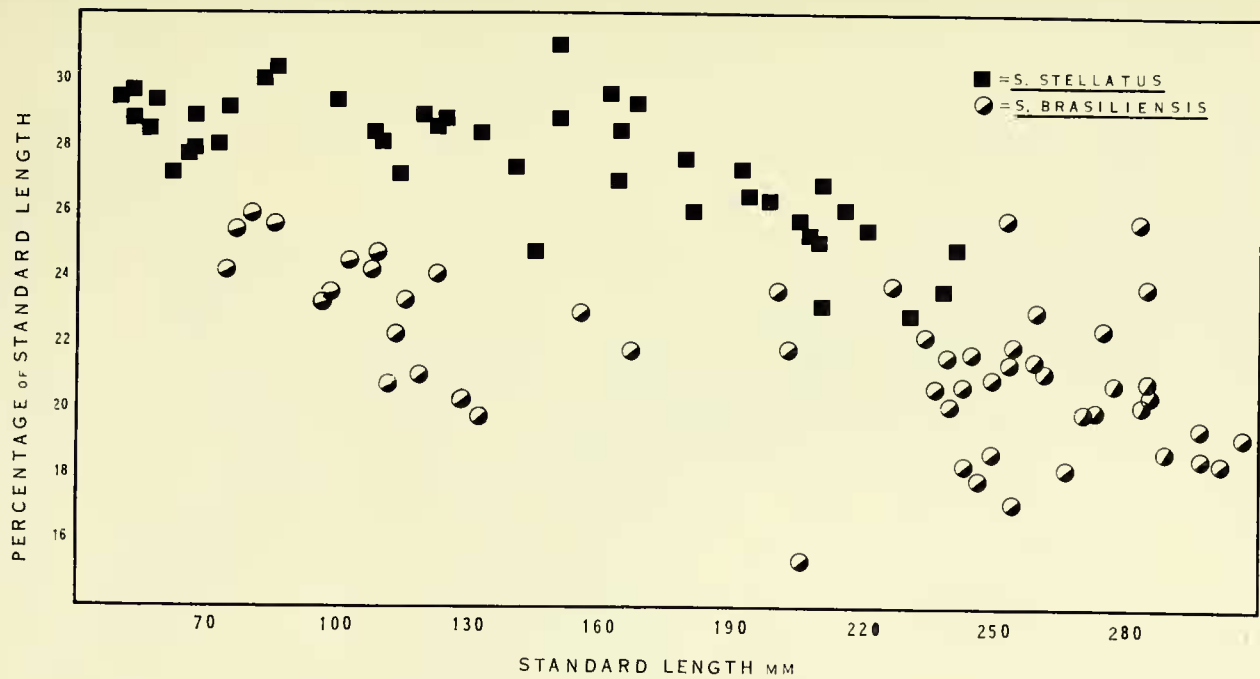


FIG. 6. Scatter diagram of pectoral fin length as a percentage of standard length in *Stromateus brasiliensis* and *Stromateus stellatus*.

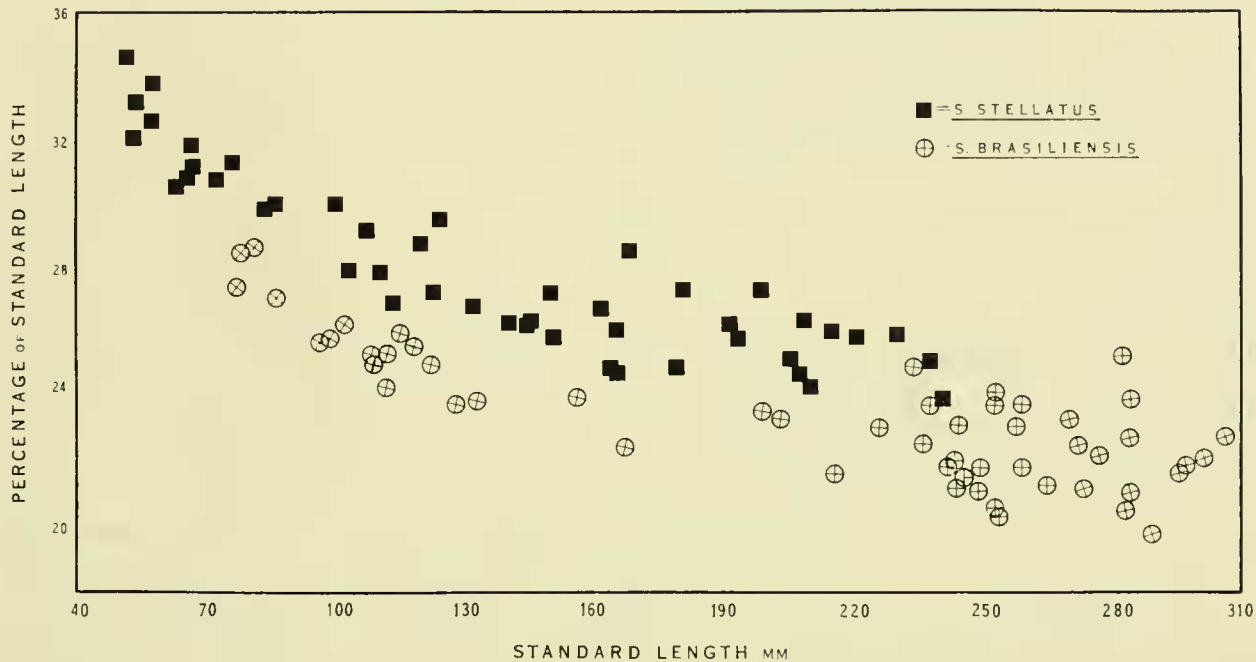


FIG. 7. Scatter diagram of head length as a percentage of standard length in *Stromateus brasiliensis* and *Stromateus stellatus*.

In the genus *Peprilus*, vertebral number varies little within a species and has been used to distinguish closely related species (Horn, 1970). In the Stromateidae, vertebral number appears to be of selective value, perhaps in association with trends in body shape.

The Atlantic population has a higher mean number of dorsal and anal fin-rays (Tables IX and X) although the populations overlap considerably in both.

Differences also exist in the relative length of the head and the pectoral fin, especially in the latter character. The Pacific form generally has both a longer head and a longer pectoral fin in relation to standard length (Text-figs 6 and 7). These differences, particularly in the length of the pectorals, may reflect divergence in behaviour and mode of life between the two populations. The shorter, more fan-like pectoral of *S. brasiliensis* may indicate a difference in locomotion and possibly in specific gravity, the fish perhaps being nearer neutral buoyancy as an adult than *S. stellatus*.

The otoliths of the two fishes are quite similar in shape and sculpturing (Text-fig. 8) but those of the Pacific population tend to be slightly more elongate than those of comparably-sized fish in the Atlantic (Text-fig. 9).

It is difficult to compare the ecology of the two forms since so little is known of this aspect, particularly of the Pacific population. Hart's (1946) discussion of the seasonal movements and potential economic importance of the Atlantic population provides a solid base on which to make future comparisons.

While little can be said about the comparative biology of the fishes, something can be said about the two habitats in which they exist and which may partially explain the observed divergence. The two coastlines differ considerably in the width of the continental shelf. The Atlantic side has a much broader shelf so that, if these fishes are restricted to the shelf region as they and other stromateids seem to be, the Atlantic has a larger preferred coastal habitat. Such a difference might be reflected in relative population size and perhaps even in size of individual fishes. From poor comparative data, the population size and individual size of *S. brasiliensis* seem probably to be larger than those of *S. stellatus*. Hart (1946) found that *Stromateus* in the Atlantic ranked third in total weight in one trawling survey and fifth in total

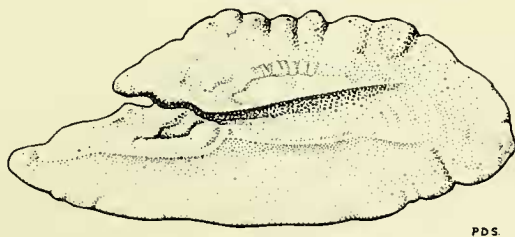


FIG. 8. Right otolith of *Stromateus brasiliensis*, median view ($\times 13\frac{1}{2}$).
From specimen 157.4 mm SL.

number during three surveys all on the Patagonian shelf. He considered the fish to be one of the most potentially valuable food fishes of the region. There is no indication to date that such a large population exists on the Pacific side.

The two coastlines are subject to different current conditions and thus have different temperature regimes at comparable latitudes. The cold, northward-flowing Peru Current pushes low temperatures farther north in the Pacific than does the cold, but weaker Falkland Current flowing northward along the Atlantic coast. The Brazil Current flows southward along the Atlantic coast to about 35° S and contributes to temperatures that are warmer than at the same latitudes in the Pacific. For example, the 25°C surface isotherm for February is at about 5° S latitude in the Pacific but at about 25° S latitude in the Atlantic (Sverdrup, *et al.*, 1942).

The two populations occupy a temperate, perhaps more nearly warm temperate, region with *S. stellatus* having a more northerly range presumably due to the effects of the Peru Current. The overall distribution in the Pacific in February, discounting any seasonal movements, would encompass a surface temperature range of from about 15° to about 20°C; in August the distribution would cover an isothermal range

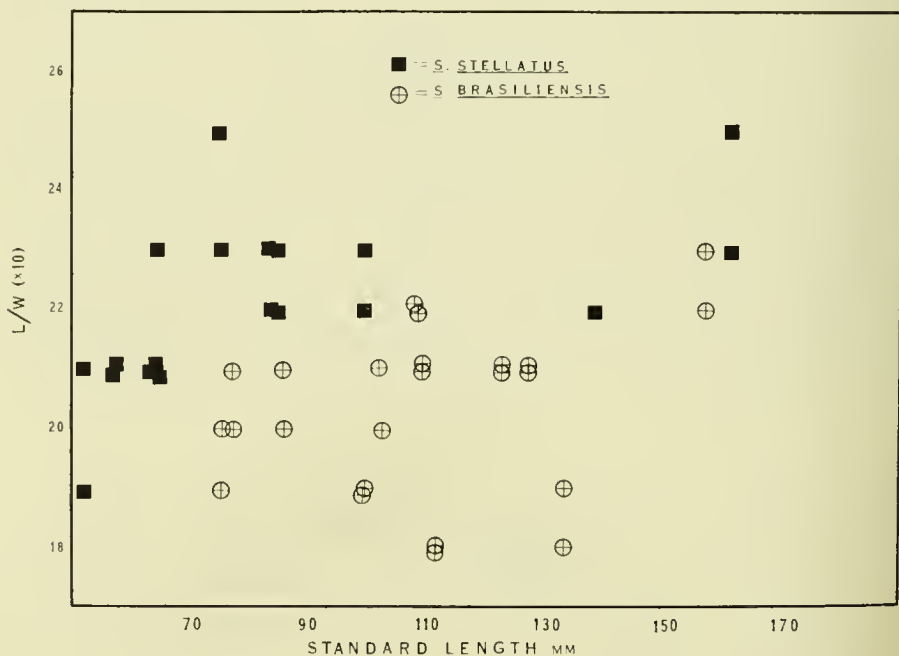


FIG. 9. Scatter diagram of otolith size in relation to standard length in *Stromateus brasiliensis* and *Stromateus stellatus*. (Length of otolith (L) divided by width (W) of otolith multiplied by 10.)

of from about 10° to about 17°C. The Atlantic population, discounting any seasonal movements, occupies a region approximately between the 10° and 25°C surface isotherms in February, and approximately between the 5° and 20°C surface isotherms in August. *S. brasiliensis* is, however, known to migrate seasonally (Hart, 1946), and the bulk of the population is probably most frequently found in the warmer parts of the range. It is not known how regularly or in what abundance *S. stellatus* occurs in the northern part of its range but probably infrequently. Most of the known collections are from farther south down to the vicinity of Chiloe Island which Ekman (1953) suggests is a possibly poorly defined southern limit for the warm temperate fauna.

In summary, the two populations appear to occupy similar temperature regimes although the Pacific one may be confined to a narrower range. The populations appear to be isolated by several hundred miles of coastline at the tip of South America and probably only in favourable periods in the past, perhaps during interglacial periods in the Pleistocene, has there been any significant migrations in either direction.

Recognition of the two populations as distinct species is based on the following evidence and reasoning: The populations show divergence in several morphological and meristic characters, and in one, vertebral number, there is no overlap. Divergence seems to be developing through both the reduction or absence of gene flow and adaptation to local conditions. The degree of divergence is comparable to that found in allopatric species of another stromateid genus, *Peprilus*, in which vertebral number is often an important character and apparently of selective value (Horn, 1970). In *Peprilus*, closely related species tend to either replace one another latitudinally along a continuous coastline (e.g., *P. simillimus* and *P. snyderi*) or parallel one another along opposite coastlines in different oceans (e.g., *P. paru* and *P. medius*; *P. simillimus* and *P. triacanthus*). A similar situation seems to exist in *Stromateus*. Less importantly, names are available in the literature for each population so that recognition of the populations at the species level requires no new names.

Position of *Stromateus* in the Family Stromateidae

Both Haedrich (1967) and Horn (1970) have suggested a Tethyan distribution for early members of the Stromateidae. Disruption of the Tethys Sea in the Miocene probably resulted in isolated populations and subsequently in the evolution of the three extant genera. Haedrich (1967 : 102) considers *Stromateus fiatola* to be the most primitive species in the family; characters considered to be primitive include the presence of pelvic fins in the young and three epural elements in the caudal structure. Haedrich considered *Pampus* to be the most highly derived genus. *P. paru*, the most highly derived species of *Peprilus*, parallels in several characteristics the advanced condition of *Pampus* (Horn, 1970 : 241).

S. brasiliensis and *S. stellatus* are then the derived members of *Stromateus* having completely lost the pelvic fins. They approach *P. snyderi*, the most primitive species of *Peprilus* (Horn, 1970 : 190), in several characteristics including the

presence of two epural elements in the caudal skeleton, the lack of pelvic fins, and an increased number of anal fin-rays. Indeed, a possible evolutionary route for *Peprilus* could have been from basic stromateid stock across the Atlantic via the southern coasts of South America to *Peprilus snyderi* presently found on the Pacific coast of Central America and Mexico. It is equally possible, however, that the ancestral stock of *Peprilus* was an element of the western Tethyan fauna.

S. brasiliensis and *S. stellatus* occupy an intermediate systematic position between the most primitive species of *Peprilus*, *P. snyderi*, and the most primitive stromateid, *S. fiatola*. The two species of *Stromateus* approach *P. snyderi* in the characters mentioned above but also retain affinities with *S. fiatola* in having a high vertebral number, a high number of dorsal fin-rays, low dorsal and anal fin lobes distinct dark spots on the body, and in attaining a relatively large size. Generic separation of the South American species might be justified but the decision should await thorough study of the osteology and other internal features.

ACKNOWLEDGEMENTS

I thank Richard L. Haedrich and N. B. Marshall for reading and offering comments on the manuscript. I also thank Sharon L. Horn for the fish drawings and Peter D. Stebbing for the otolith drawing. This work was supported by the National Science Foundation—the early part by a Woods Hole Oceanographic Institution postdoctoral fellowship (Grant no. GZ-259) and the final part by a NATO postdoctoral fellowship at the British Museum (Natural History).

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